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III. *Observations on the Class of Animals called, by Linnæus, Amphibia; particularly on the Means of distinguishing those Serpents which are venomous, from those which are not so.*
By Edward Whitaker Gray, M. D. F. R. S.

Read December 18, 1788.

OF the various classes of the animal kingdom, no one has been so little attended to as the class, called by LINNÆUS, Amphibia. What he himself did in that class (though far superior to what any other person has done) was evidently done in a hurry; false references are, at least, as common in that, as in any other part of his works, and many of his descriptions are given in a very careless manner; others there are, however, which are truly worthy of their author, and in which the specific characters are pointed out with that clearness and precision, which so eminently distinguish the descriptions of LINNÆUS from those of all his predecessors.

In the construction of the class, LINNÆUS has been particularly unfortunate; as he has erred, not only in making an unilocular heart one of the characters of it, but also in making the cartilaginous fishes a part of it. I think it needless to mention the causes which led him to this latter error; every anatomist now agrees that the Amphibia Nantes are not furnished with lungs; and every naturalist is convinced of the propriety of removing them, from the class of Amphibia, to that of Fishes. I shall only observe that, by the removal, the name of the class

class (which some naturalists have cavilled at) becomes much less objectionable ; there being few genera, in the two orders of which it is now presumed to consist, which do not contain animals to which the term amphibious may, with some propriety, be given ; whereas, in the order of Nantes, not one species occurs which has the smallest claim to that title. With respect to the other error I noticed (*viz.* that of supposing the hearts of the Amphibia to be single) it would be easy to shew that it was not an uncommon one, at the time LINNÆUS formed his system. And indeed he appears to have been led into it, by following an author whom he probably supposed of too great fame not to be safely relied on. At least, in defence of his opinion, he quotes the following words of BOERHAAVE. “ *In omnibus animalibus in quibus sanguis non calet, ventriculus cordis est unicus.*” Whether the hearts of all the different genera, of which the class is composed, have yet been accurately examined ; and whether an exact similarity of structure is found throughout the class ; are questions I do not mean, at present, to examine. It is sufficient for my purpose to observe, that the hearts of most of the Amphibia are now well known to be double, with an immediate communication between the two cavities ; which structure seems peculiarly adapted to that change of element, which (as I before observed) many of them can, for a time, support ; and thereby furnishes another argument in favour of the name LINNÆUS has given to the class.

To consider the structure of the heart, however, is not absolutely necessary in forming the characters of the class : the animals of which it consists being sufficiently distinguished from all others, by having cold red blood, and breathing by means of lungs. These two characters render the class perfectly distinct from the rest ; the two superior ones, *viz.*

Mammalia

Mammalia and Birds, having warm blood; and the three inferior ones, *viz.* Fishes, Insects, and Worms, not being furnished with lungs.

In his generic characters, LINNÆUS has been more successful than in those of the class; inasmuch that they may, I think, be considered as the best hitherto given. Whoever will be at the pains of comparing LINNÆUS's genera of Amphibia with those of GRONOVIVS, will find, that the generic characters of the former, though few in number, are precise and distinct; while those of the latter, though more numerous, are vague, indistinct, and sometimes inaccurate. As a glaring instance of inaccuracy, I need only refer to the Chamæleon, which by GRONOVIVS is made a distinct genus, of which one of his characters is, *Pedes unguibus destituti*; whereas, in fact, the feet of that animal are furnished with very distinct, and pretty large, claws.

But though LINNÆUS's genera of Amphibia are, upon the whole, well formed, it must be allowed to be a great imperfection in them, that the venomous serpents are not separated from the others.

From some expressions of his, in the Preface to the *Museum Regis*, and in the Introduction to the Class Amphibia, in the *Systema Naturæ*, it seems, that he thought it not easy to distinguish them, by any external characters; and his ideas respecting the venomous fangs themselves were (as we shall see hereafter) so vague and confused, that it was hardly possible for him to attempt to found a generic distinction upon them*.

* As a sort of comparative excuse for LINNÆUS, it may be observed, that GRONOVIVS (though he made two more genera of Serpents than LINNÆUS) did not separate the venomous ones; neither has he distinguished them by a mark (as LINNÆUS has) or by any other means.

Whether venomous Serpents can be, with certainty, distinguished from others, and if so, how they are to be known, is what I mean to consider in this Paper; in doing which I shall examine, first, how far they may be distinguished by any external characters; secondly, supposing the venomous fangs to be the only certain criterion, how those fangs are to be distinguished from common teeth.

Though Serpents, by their internal organization, naturally belong to the third class of the animal kingdom, they are, in their external form, more simple than most of the animals belonging to the three inferior classes; their external characters must consequently be very few. I shall first examine those of the head; and, as all venomous Serpents (so far as our present experience extends) are contained in the three first of LINNÆUS's genera, I shall, at present, consider only those three.

In the first genus, *Crotalus*, the head is broader than the neck, depressed or flat at top, and covered with small scales. These three characters are particularly observable in the three intermediate species *horridus*, *Dryinas*, and *Durissus*. In the *miliarius* the scales of the head are rather larger than in the others. The *mutus* I have never seen; but it certainly should not be placed among the *Crotali* *.

As all the species of this genus are venomous, one is naturally led, by the examination of it, to consider the fore-mentioned characters as being, in some measure, proper to venomous serpents. In order to see how far they are so, I shall, for the present, pass over the next genus, *Boa*, and consider

* LINNÆUS's reason for not placing it among the *Boæ* seems to have been, that he supposed none of them were venomous. He appears, however, to have had his doubts about the *contortrix*. I have examined it, and am convinced it is venomous.

that which follows it, Coluber. In that genus are many venomous species, and it is very certain that, in general, they have the fore-mentioned characters; examples of which may be seen in the Atropos, Ceraſtes *, atrox, Berus, and others. It is, however, equally certain, that there are some in which they are not to be found. As an example of this, I need only mention the Naja, a species well known to be very venomous; the head of which is neither depressed nor broad, is covered with large scales, and is, in every respect, a complete exception to what has been said, respecting the heads of venomous Serpents.

Since then, there are venomous Serpents in which the fore-mentioned characters, *viz.* a broad and depressed head, covered with small scales, are not to be found; I shall next examine whether those characters are to be found in any of those Serpents which are not venomous. In the genus Coluber there are very few (except venomous ones) which have the head much broader than the neck; and of those few, I believe, every one has the head covered with large scales. But in the genus Boa, though no species is venomous, except the con-tortrix, almost every one has the head broad, depressed, and covered with small scales. The canina, Constrictor, hortu-lana, besides some others not described by LINNÆUS, furnish

* The Ceraſtes is not marked by LINNÆUS as a venomous species. He probably depended upon HASSELQUIST's description, which I suspect to have been made from a mutilated specimen. Mr. ELLIS's description in the Philosophical Transactions, Vol. LVI. p. 287. is only a Translation of HASSELQUIST's. But he observes, that Dr. TURNBULL told him it was venomous. That it is so, I have not the smallest doubt, though in the only specimen I have seen of it the fangs were wanting, IMPERATO, who has given a figure of it (Hist. Nat. p. 734. Ed. Nap.), says it is very venomous.

examples of this. It muſt, however, be confeſſed, that the general character of the head of the Boa, though differing very widely from that of thoſe Colubri which are not venomous, is not quite that of the *Crotalus*; but the difference, though very obvious to a perſon accuſtomed to the examination of Serpents, is perhaps not eaſy to be fully expreſſed in words. It ſeems, however, to conſiſt principally in a lateral compreſſion, and elongation, of the anterior part of the head, ſo as to form a kind of ſnout. Hence the trivial name of *canina* is given by LINNÆUS to one of the ſpecies.

From the characters of the head (as the trunk affords none deſerving conſideration) I ſhall proceed to thoſe of the other extremity.

In the *Crotali* I have never found the tail (excluſive of the Rattle) to exceed one-ninth part of the whole length; ſometimes I have found it much ſhorter. In ſome of the venomous Colubri, the proportion is ſtill leſs. In the *Atropos* I found it only one-thirteenth. In the Engliſh Viper (*Coluber Berus*) it is commonly about one-seventh or eighth. In ſome venomous ſpecies, however, the proportion is ſomething greater. In the *Naja* I have found it as much as one-fixth; which proportion is, I believe, as great as I have ever obſerved: but that I may be ſure to keep within the truth, I will only ſay, that I have never met with a venomous Serpent, the tail of which was equal to one-fifth of the whole length*.

* The tail of the *Boa contortrix* is ſaid by LINNÆUS to be one-third; but his own enumeration of the *Scuta* ſufficiently ſhews that this muſt be an error. The *Coluber Leberis*, *Dipſas*, and *myſterizans* appear, by the number of ſcales under their tail, to furniſh exceptions to what I have ſaid. The two firſt I have never ſeen, but ſuſpect they are not venomous; that the laſt is not ſo I am very certain, having examined many ſpecimens of it.

With respect to those Colubri which are not venomous, it must be confessed, that there are many whose tails are within the limits assigned to the venomous ones. In the Coluber *Æsculapii*, *doliatus*, *getulus*, and some others, the tail is not, in general, more than one-seventh of the whole length. In the *lemniscatus* I have found it not exceeding one-twelfth or thirteenth; but I know no other Linnæan species in which it is so short. In the greater number, however, the proportion of tail is more considerable; in many, it is full one-third. In the *Ahætulla*, and in some species not described by LINNÆUS, I have seen it more than two-fifths; but have never met with a species in which it was quite so long as the trunk, or half of the whole length.

I have not considered the *Boæ*, because none of the Linnæan species, of that genus, have their tails either remarkably long, or short; but, in two species, not described by LINNÆUS, I found the tail very little exceeding the proportion I have assigned to the Coluber *lemniscatus*.

In the thickness of the tail, or in the acuteness of its termination, I have observed no difference worth remarking. In every species of the three first genera, the tail is thinner than the trunk; and in most of them it is more or less acute. The few exceptions I have observed were, I believe, none of them venomous; but they are too few to deserve any particular consideration.

A character of great use in distinguishing the species of Serpents, and which was not overlooked by LINNÆUS, is, that elevated line, or carina, with which the scales of many species are furnished. In order to shew how far this is to be considered as serving to distinguish venomous Serpents from others, I need only observe, that I have examined one hundred and twelve species of Serpents, not venomous, belonging to the three first

genera; and find that eighty of them have smooth scales, and thirty-two only have carinated ones. Of venomous Serpents I have examined twenty-six; of which number, twenty have carinated scales, and only six have smooth ones. Upon the whole, therefore, carinated scales must be considered as being, in some measure, a character of venomous Serpents.

In what I have hitherto said, I have considered only the three first genera of Serpents; I shall now make some remarks upon the three last.

These three (*viz.* Anguis, Amphibæna, and Cæcilia), besides the characters assigned them by LINNÆUS, have some others which are common to all, and which render them very different, in their external appearance, from any of the three first genera. These are, a very thick and obtuse tail, and a head which is very indistinct*, and furnished with very small eyes. This last character (*viz.* very small eyes) is sometimes, though very rarely, met with among the Colubri, for instance, in the *lemniscatus*; in the three last genera, however, it takes place, I believe, without exception. The thickness of the tail is also common to every species; and though in the Anguis bipes, and in another species, not described by LINNÆUS, but figured in BROWNE's History of Jamaica (Tab. XLIV. fig. 1. †), the tail has an acute termination, yet in both those species, especially in the last, it continues thick to the end, and becomes suddenly sharp, being what in botanical language would be called, *obtusa cum acumine*. With respect to the proportionate length of tail, however, it is very remarkable, that the genus

* This indistinctness of the head, which is more or less common to each genus, is in the Amphibæna so considerable, as to have given rise to the supposition of that Serpent's having a head at each end.

† This figure is, by LINNÆUS, erroneously quoted as his Anguis lumbricalis.

Anguis affords examples of much less proportion, and also of much greater, than is to be found in any of the three first genera. In the Anguis Scytale the tail is not above one-twentieth of the whole length; in the maculata it is not above one-fortieth; yet in the Anguis fragilis, and in the ventralis, the tail is always longer than the trunk, or, in other words, is more than half the whole length. Indeed, in one specimen of the last mentioned species, I found the tail nearly two-thirds of the whole length. It may, however, be questioned whether that species is really an Anguis, or a Lacerta*.

I shall make no further remarks on the external characters of Serpents; the principal inferences to be deduced from those I have already made, are the following.

1st, That a broad head, covered with small scales, though it be not a certain criterion of venomous Serpents, is, with some few exceptions, a general character of them.

2dly, That a tail under one-fifth of the whole length, is also a general character of venomous Serpents; but, since many of those which are not venomous have tails as short, little dependence can be placed upon that circumstance alone. On the other hand, a tail exceeding that proportion, is a pretty certain mark that the species, to which it belongs, is not venomous.

3dly, That a thin and acute tail is by no means to be considered as peculiar to venomous Serpents; though a thick and obtuse one is only to be found among those which are not venomous.

* The Anguis ventralis of LINNÆUS, is so very like the Lacerta apoda, described by PALLAS, in Vol. XIX. of the *Novi Comment. Petrop.* as to render it doubtful whether it may not be the same. When I first examined it, I considered it as a Lacerta, on account of the projecting snout along the body, and the open ears; but I have since met with a specimen which had two large echinated *Pores* (as they are called) a character which is, I believe, peculiar to Serpents.

4thly,

4thly, That carinated scales are, in some measure, characteristic of venomous Serpents, since in them they are more common than smooth ones, in the proportion of nearly 4 to 1; whereas, smooth scales are, in those Serpents which are not venomous, more common, in the proportion of nearly 3 to 1.

Upon the whole therefore it appears, that though a pretty certain conjecture may, in many instances, be made, from the external characters; yet, in order to determine, with certainty, whether a Serpent be venomous or not, it becomes necessary to have recourse to some more certain diagnostic. This can only be sought for in the mouth; I shall therefore next consider, how the fangs, with which the mouths of venomous Serpents are furnished, are to be distinguished from common teeth.

To those who form their ideas of the fangs of venomous Serpents, from those of the Rattle-snake, or even from those of the English Viper, it will appear strange, that there should be any difficulty in distinguishing those weapons from common teeth; and indeed the distinction would really be very easy, were all venomous Serpents furnished with fangs as large as those of the fore-mentioned species. But the fact is, that in many species the fangs are full as small as common teeth, and consequently cannot, by their size, be known from them; this is the case with the *Coluber laticaudatus**, *lacteus*, and several others. I cannot, however, better demonstrate that the distinction, between the venomous fangs and common teeth, is not very obvious, than by shewing how very vague and erroneous

* This species is by LINNÆUS reckoned venomous, in the *Museum Regis*, though the mark is not affixed to it in the *Systema Naturæ*. To me it appears to be certainly venomous, and is the only water Serpent I have met with that is so.

LINNÆUS's ideas about them were; nor can I better prove the want of information on this subject, than by observing that, erroneous as the ideas of LINNÆUS were, no one, that I know of, has yet attempted to furnish more correct ones.

LINNÆUS thought the fangs might be distinguished by their mobility; this, at least, may be fairly inferred, from his never mentioning them in the *Museum Regis*, without adding the epithet *mobilia*, except in one instance (the *Coluber aulicus*); and, in that very instance, the want of mobility in the supposed fangs appears evidently to raise doubts in his mind, whether they are really fangs or not. His words are, “*Dentes, five tela, duo, rigida, parva, non mobilia.*” These doubts, respecting the above-mentioned species, I am not able to remove, as I am not sure that I have ever seen it*. But with regard to mobility, considered in general as a character of venomous fangs, I must assert, not only that I have never found it so, but also, that I have never been able to discover in them any thing which I thought could properly be called mobility. I have, indeed, sometimes found some of them loose in their sockets; but then I have found others, in the same specimen, quite fixed. The same thing was observed both by Dr. NICHOLLS †, and by the Abbé FONTANA ‡, in the common Viper, even during life. The loose fangs may be such as have not yet been firmly fixed in their socket, or they may have been loosened by some accident: for I suspect that the fangs may be at any time loosened, and even displaced, by a small degree of violence; and that, perhaps, may be one

* I have seen one, which agreed pretty well with LINNÆUS's description; if that was really his species, it is not venomous.

† Appendix to Dr. MEAD's Account of the Viper.

‡ FONTANA, *Traité sur le Venin de la Vipere*, chap. 1st and 2d.

reason why there is always a certain number of small fangs, near the base of the full grown ones, ready to enlarge and take their place, if they should be, by any accident, torn out.

LINNÆUS seems also to have thought that the fangs might be known by their situation. In the Introduction to the class Amphibia in the *Systema Naturæ*, he says they are, "*Dentibus simillima sed extra maxillam superiorem collocata*;" and in the description of the *Crotalus Dryinas*, in the *Amœnitates Academicæ*, he says, "*Dentes ejus duo canini uti in reliquis venenatis Serpentibus non in maxillis hærent, iis enim vulnerando, non autem ictus infligendo utitur.*"

These two quotations shew, that LINNÆUS thought the situation of the fangs different from that of the common teeth; the last also shews that he thought their mode of action influenced by it. What difference in situation may be found by accurate dissection, it is foreign from my present purpose to enquire; I am, however, very certain that common examination* will not discover any difference, in that respect, between the fangs of venomous Serpents, and the teeth of others.

But the most singular opinion of LINNÆUS, respecting the venomous fangs, was, that they were sometimes fixed in the base of the jaw. Of this he has given two instances in the *Museum Regis*. One in the description of the *Coluber severus*, of which he says, "*Hastæ mobiles solitariae versus basin maxillarum interius adhærent.*" The other in that of the *Coluber stolatus*. His words there are, "*Tela mobilia ad basin maxil-*

* By common examination I mean such as may be made without dissecting, or otherwise damaging, the specimen to be examined; and such only do I suppose allowable in the distinction I am seeking to establish.

*“ larum affixa, ut vix vulnerare valeat bestes, solum cibos veneno
“ inficere.”*

LINNÆUS's opinion respecting the use of the fangs, in the last mentioned species, appears to me not very clearly expressed *. But I have quoted both descriptions, merely to shew that LINNÆUS thought the fangs were sometimes placed in the base of the jaw ; an idea for which I have never been able to discover any foundation. The first of the two species in question I have never seen ; of the stolatus I have examined several specimens, and am convinced it is not venomous.

I shall not dwell any longer on the false notions which have been entertained, respecting the fangs of venomous Serpents, but shall proceed to shew how, in my opinion, they may be most easily, and most certainly, distinguished from common teeth.

With respect to their size, I have already observed that it is very various, consequently no certain judgement can, in all cases, be made from that circumstance. In some species they are so large, that their size alone sufficiently distinguishes them from common teeth ; but in others they are so small, that it is very difficult to discover them.

The size of the common teeth also varies very much, in different species. In the Coluber mycterizans they are remarkably large, especially those which are situated near the apex of the upper jaw ; which circumstance probably helped to lead LINNÆUS into the erroneous opinion he entertained, that this Ser-

* LINNÆUS's opinion seems not unlike that of the Abbé FONTANA, who (in the work already mentioned, chap. 12.) supposes the poison of the Viper may be of use, to the animal, in digestion. To me the venomous fangs have ever appeared to be merely offensive weapons ; nor can I see greater difficulty in supposing such a weapon, with the power of injecting poison, placed in the head of a Viper or Rattle-snake, than in supposing such an one, with a similar power, placed in the tail of a Wasp or Hornet.

pent was venomous. But in many species the teeth are so small, that it is impossible to discover, merely by looking into the mouth, that the animal has any. Yet in that case they may be very easily detected, by drawing a pin (or any other hard substance) with a moderate degree of pressure, along the edge of the jaw, from the apex to the angle of the mouth, when they will be felt to grate against the pin, like the teeth of a saw.

Although the size of the venomous fangs is very various, their situation is, I believe, always the same; namely, in the anterior and exterior part of the upper jaw, which situation I consider as the only one in which venomous fangs are ever found. But as, in those Serpents which are not venomous, common teeth are found in that part of the jaw, it is plain that we cannot, by situation alone, distinguish one from the other. They may, however, be distinguished with great ease, and I believe also with great certainty, by the following simple operation. When it is discovered that there is something like teeth in the fore-mentioned part of the upper jaw, let a pin be drawn, in the manner already described, from that part of the jaw to the angle of the mouth (which operation may, for greater certainty, be tried on each side). If no more teeth are felt in that line, it may I believe be certainly concluded, that those first discovered are what I have distinguished by the name of fangs, and consequently, that the Serpent is a venomous one *. If, on the contrary, the teeth first discovered are found not to stand alone, but to be only a part of a complete row, it may as certainly be concluded, that the Serpent is not venomous.

* If a specimen should be met with, in which no teeth, of any kind, can be discovered in the margin of the upper jaw, the presumption is, that it is a venomous Serpent, which has lost its fangs; but I have never met with such an one, except the Coluber Ceraastes already mentioned.

In the upper jaw, both of venomous Serpents and others, besides the teeth already spoken of, there are two interior rows; consequently, the distinction I have endeavoured to establish might be expressed in other words, by saying, that all venomous Serpents have only two rows of teeth, in the upper jaw, and all others have four*. I think it better, however, to leave the interior rows out of the question, as, in many species, the teeth of which they are composed are so small, as to make it very difficult to discover them. Indeed, in two species of *Anguis*, I can hardly be sure that I have discovered them; but as, in every other species, I have never failed to do so, I presume I may, with very little risk of error, assert, that all Serpents whatever are furnished with them; and that those only, which are not venomous, have the exterior rows.

What I have said sufficiently shews that LINNÆUS's ideas, respecting venomous serpents, were such as did not permit him to separate them from the others; if the method I have proposed shall be found to render the distinction of them sufficiently clear and easy, it naturally follows, that they should be made generically distinct. Some other reforms might also be made in LINNÆUS's class of *Amphibia*, the consideration of which I do not mean, at present, to enter further into. But, before I conclude, I think it necessary to notice an inaccuracy of LINNÆUS, of a different kind from those I have already pointed out.

* GRONOVIVS, of whose inaccuracy I have already given one instance, in describing the *Crotalus Durissus*, in his *Museum Ichthyologicum*, says it has no teeth, except the venomous fangs. KLEIN, in his *Tentamen Herpetologiæ*, has gone still further, having actually made a genus of Serpents without teeth, which he calls *Anodon*. He appears not to have examined the mouth of a single species; but to have depended intirely upon the descriptions of SEBA.

In the Preface to the *Museum Regis*, and in the Introduction to the class *Amphibia*, in the *Systema Naturæ*, LINNÆUS says, that the proportion of venomous Serpents to others, is 1 in 10; yet in the *Systema Naturæ*, in which the sum total of species is one hundred and thirty-one, he has marked twenty-three as venomous, which is somewhat more than 1 in 6. How he came to be so much at variance with himself, I know not; but the last mentioned proportion seems to me to be not far from the truth; as I find that I have examined one hundred and fifty-four species of Serpents, of which number twenty-six appear to be venomous.

I have already mentioned, that the *Coluber stolatus* and the *mycterizans*, though marked by LINNÆUS as venomous Serpents, certainly are not so; and that I suspect the same may be said of the *Leberis*, and *Dipsas*. I have also observed, that the *Boa contortrix*, *Coluber Ceraastes*, and *laticaudatus*, none of which are marked in the *Systema Naturæ*, are all of them venomous; to these last may be added the *Coluber fulvus*.

If LINNÆUS's species were all accurately examined, I have no doubt but more errors, of both kinds, would be found; for it must be observed, that though I have examined a greater number of species than LINNÆUS, not above half that number are of those described by him; consequently there remains more than one-third of his species which I have never seen. The number I have examined, however, seems to me sufficiently great to warrant the inferences I have drawn from that examination. That some exceptions to them might be found, by the examination of a greater number, is very possible; but, if these observations shall tend to rectify the false notions which have been entertained respecting venomous Serpents, and to render the distinction between them and others more clear, I trust they will be thought not totally useless.